



Socioeconomic influences on the attitudes, knowledge, and perceptions of people about the making of *Junina* bonfires: A case study in two communities in Northeast Brazil

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ABSTRACT

In Northeastern Brazil, the tradition of building bonfires is especially common, particularly during the June festivals. This study aimed to examine the influence of socioeconomic factors on the construction of June bonfires, as well as to analyze the local attitudes, knowledge, and perceptions about this practice in two northeastern communities. Semi-structured interviews were conducted during 2022 and 2023 to collect socioeconomic data and perceptions of the risks associated with bonfires. A Generalized Linear Mixed Model was used to relate the dependent variables (knowledge and volume of wood per person) to the independent variables (sex, age, education level, number of household members, and family income). Additionally, the Collective Subject Discourse method was applied to analyze the population's perceptions of the impacts of bonfires on health and the environment. The results show that family income is positively linked to the amount of wood used, with elderly individuals and those with lower education levels also using more wood. Although environmental impacts were rarely perceived, respiratory problems were frequently mentioned. These results highlight the need for education and awareness of the risks associated with cultural practices and suggest management strategies to protect forest areas that consider local practices.

Keywords: conservation, culture, ethnobotany, traditional festivals, woody plants.

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Introduction

Evidence indicates that the use of timber resources by human groups has been fundamental from an evolutionary and cultural perspective (McNeil, 2012; Albuquerque & Alves, 2014a; Albuquerque *et al.*, 2015), especially for cooking food, heating systems, and in some magical-religious rituals (rituals and various cultural manifestations) (Medeiros *et al.*, 2012; Mendes *et al.*, 2023). Currently, timber use is more evident among populations living in areas adjacent to forest resources, as a strategy to meet their family subsistence needs. In this sense, we can observe these behaviors more clearly in communities that have historically suffered from economic and social vulnerabilities, such as local communities in northeastern Brazil (Medeiros *et al.*, 2012; Sobral & Albuquerque, 2016; Silva *et al.*, 2016a; Mendes *et al.*, 2023).

It is important to highlight that there may be peculiar differences related to timber uses and their purposes, which are not investigated in depth in ethnobiological studies. The use of timber for subsistence purposes, such as for cooking, requires specific resource selection criteria, based on their qualities, because efficient wood for daily use implies fewer incursions into the forest and consequently fewer risks for the collector, since in some areas the use of timber is prohibited in Brazil (Medeiros *et al.*, 2012; Ramos *et al.*, 2016; Mendes *et al.*, 2023). However, religious magical use, as is the case with June bonfires in Brazil, is an annual use and a symbolic practice, which is not related to the daily survival of a certain group of people. Therefore, the creation of June bonfires may not require wood perceived as being of good quality and risks of collection in the forest environment. (Almeida *et al.*, 2008). About the construction of June bonfires, it occurs during the June festivities in June, especially in northeastern Brazil, in celebration of religious entities such as Saint Anthony (June 13), Saint John (June 24) and Saint Peter (June 29) (De Lima Martins *et al.*, 2004; Sandroni *et al.*, 2016). This practice, deeply rooted in northeastern cultural and religious traditions, transcends generations and remains significant regardless of the environmental and social context (Lima *et al.*, 2004; Almeida *et al.*, 2008). Thus, in this sense, the differences inherent in the uses of wood for domestic and magical-religious purposes need to be further investigated, as these differences may have implications for the conservation of natural resources, since domestic use requires resources with specific characteristics (Mendes *et al.*, 2023), while for making fires, the wood does not need to be of good quality and people may also seek exotic and invasive species (Almeida *et al.*, 2008). In addition, the cultural uses of some species are associated with their conservation, given their importance (Cocks & Dold, 2008; Cocks *et al.*, 2012).

In addition to the conservationist implications of the approach to the use of wood for magical and religious purposes, it is also necessary to understand the

socioeconomic factors that drive and shape the knowledge and use of wood for this purpose, given its specificities. The creation of June bonfires in Brazil, a practice widely spread in the Northeast region, with Catholic influence, may have another dynamic of knowledge and use of wood, with social and environmental implications distinct from domestic use, and investigating such factors will contribute to the theoretical framework of Ethnobotany. Therefore, a more accurate approach to understanding this phenomenon would be to test the influence of socioeconomic variables, which have already been widely studied to understand the knowledge and use of wood for domestic purposes, as well as for magical-religious uses. For example, empirical evidence shows that socioeconomic variables emerge as explanatory predictors of knowledge, use, selection, and preference for timber resources for domestic purposes, especially for fuel use (Gavin & Anderson, 2007; Medeiros *et al.*, 2011; Paniagua-Zambrana *et al.*, 2014; Biara *et al.*, 2021).

In this regard, Medeiros *et al.* (2011) demonstrated that variables such as gender, age, income, education level, and number of residents in the household have a direct influence on timber use. Other studies show that while men demonstrate greater familiarity with handling wood for construction (Ramos & Albuquerque, 2012), women are more knowledgeable about the resources used for cooking fuel (Machava-António *et al.*, 2022). On the other hand, studies such as the one conducted by Friman (2024) reveal that these gender patterns do not always hold, suggesting that the differences found in the studies may be directly linked to the social roles assigned to individuals according to their cultural and social realities (Pfeiffer & Butz, 2005).

Concerning the age variable, research shows that older people accumulate significant knowledge about the use of timber resources, resulting from various opportunities over time to become familiar with these resources (Voeks, 2007; Ramos *et al.*, 2008a; Oliveira & Neto, 2012). In addition, populations with low purchasing power and large families, especially those living in rural areas, have greater use of and dependence on timber resources (Gavin & Anderson, 2007; Medeiros *et al.*, 2012; Bhatt *et al.*, 2016; Assis *et al.*, 2020). In this context, it is essential to investigate whether the patterns of wood use described in the literature for different purposes also apply to the magical-religious category, since this type of use has a different periodicity from extraction for food preparation or other everyday practices and specific characteristics, already mentioned, which makes this analysis even more relevant, especially given the scarcity of studies on the subject.

In addition to socio-economic aspects, the perception of people regarding timber resources can influence their knowledge and use of them. Perception, which is how individuals interpret and understand the stimuli around them, is shaped by cultural experiences and personal contexts, characterized by a subjective interpretation of external reality (Silva *et al.*, 2016a). Investigating

people's perceptions of timber resources can be useful for understanding, for example, changes in the landscape and their possible causes, the criteria involved in selecting, using, and preferring these resources (Silva *et al.*, 2016c; Mendes *et al.*, 2024).

However, in the case of the June festivities, there is still little exploration in ethnobiological studies in the context of how people perceive the impact of using timber resources to build bonfires, which can cause other environmental and social impacts (Soverino, 2016; Arbex *et al.*, 2004; Campos *et al.*, 2017; Colares *et al.*, 2021), in addition to the direct impact of plant species through extraction (Ramos *et al.*, 2016). For example, the burning of bonfires causes CO₂ emissions during the June period, in addition to polluting the air, which can cause serious respiratory problems and episodes of burns, especially among children (Arbex *et al.*, 2004; Campos *et al.*, 2017; Colares *et al.*, 2021). The perception of the risk of these impacts on health may be influenced mainly by the periodicity of these festivities, the fact that they are infrequent may lead people to underestimate their possible impacts, unlike other illnesses that are frequent in the lives of individuals (Santoro *et al.*, 2015; Nascimento *et al.*, 2016).

In this sense, we sought to understand what factors might influence knowledge of people, uses, and perceptions of the practice of making bonfires during the June period in two communities in the state of Alagoas, in northeastern Brazil. We sought to answer the following questions: How do socio-economic variables influence the knowledge and use of wood for bonfires? How do people perceive the health and environmental impacts of building bonfires?

Material & Methods

Study Area

Community Lagoa do Junco, municipality of Santana do Ipanema

The study was initially conducted in the Lagoa do Junco community, a peri-urban locality located in the city of Santana do Ipanema (Figure 1), in the middle *Sertão* of Alagoas, Northeastern Brazil, approximately 209 km from the capital municipality of Maceió, covering a territorial extension of 436.160 km². According to the latest IBGE census (Instituto Brasileiro de Geografia e Estatística – IBGE,

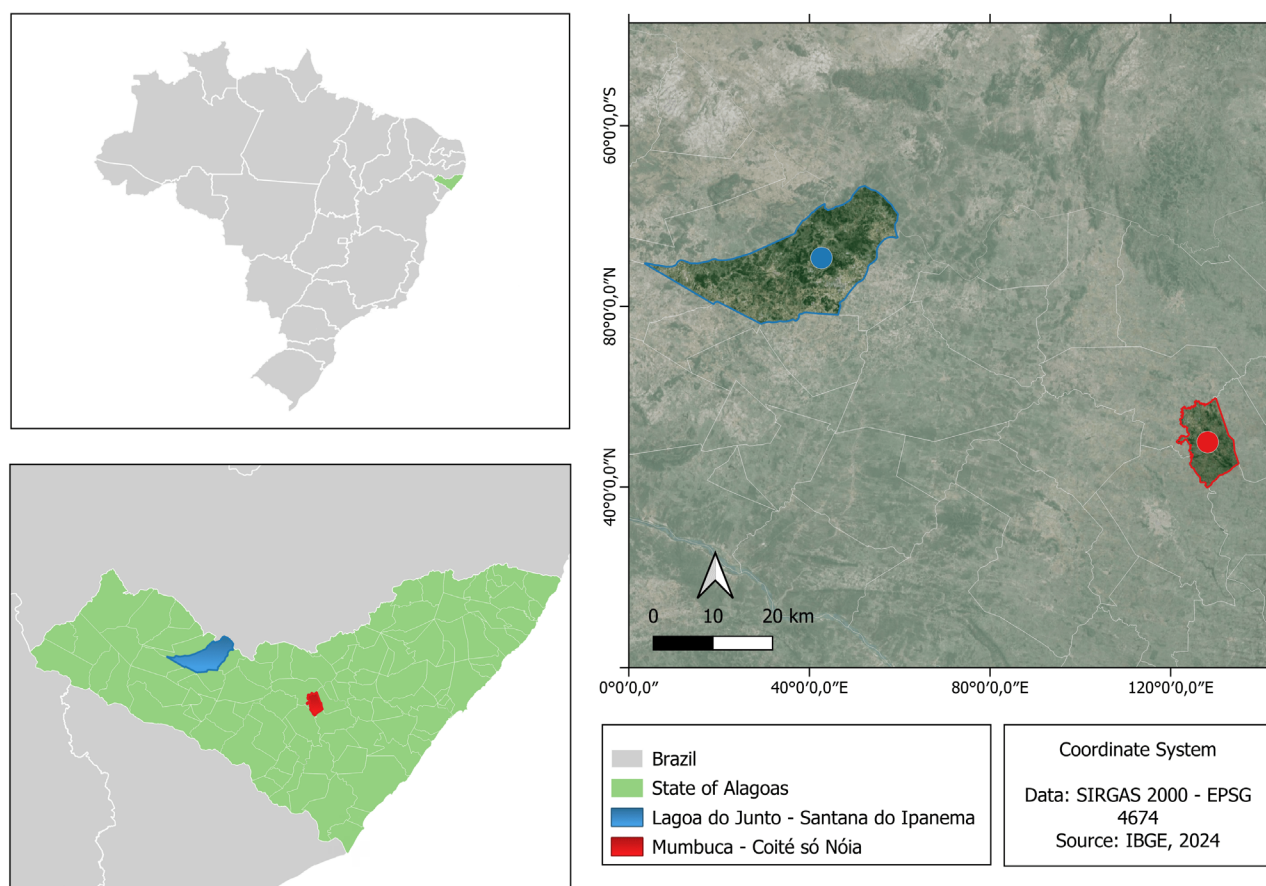


Figure 1. Location of the communities Lagoa do Junco and Mumbuca in the municipalities of Santana do Ipanema and Coité do Nóia, Alagoas, Brazil.



2024), the city has a population of 47,910 inhabitants, resulting in a population density of 102.61 inhabitants/km². Located at an altitude of 272 meters (Latitude: 9° 21' 49" S, Longitude: 37° 14' 54" W), the region is characterized by a local steppe climate (classified as BSh according to Köppen & Geiger), with an average temperature of 25.2 °C and an annual average rainfall of 461 mm.

According to information provided by community health agents in Lagoa do Junco, this locality has a population of 511 individuals distributed across 102 families. The community is subdivided into two distinct areas, each under the responsibility of a community health agent, who voluntarily assisted in guiding the approach to the interviewees. Regarding the prevalent religious orientation, there is a predominance of Catholicism, evidenced by the presence of a Catholic church near the entrance of the community. Additionally, other Christian and African-rooted religious expressions coexist. Locally, there are identifiable commercial establishments and public infrastructure, including a basic education institution, a municipal daycare center, a Basic Health Unit (UBS), and a surrounding forest area characterized by the Caatinga ecosystem, according to data from the Brazilian Institute of Geography and Statistics (IBGE) from 2019.

Community Mumbuca, municipality of Coité do Nóia

The second study area is located in the central region of Alagoas, Northeastern Brazil (Figure 1), approximately 228 km from the capital, Maceió. The municipality covers an area of 88.759 km² and recorded 10,810 inhabitants in the last IBGE census (Instituto Brasileiro de Geografia e Estatística – IBGE, 2024), resulting in a population density of 121.79 inhabitants/km². With an approximate altitude of 280 meters (Latitude: 9° 37' 56.0" S, Longitude: 36° 34' 43.0" W), it has a tropical climate classified as Aw, with an average temperature of 24.4 °C and an annual average rainfall of 755 mm, according to Köppen & Geiger.

According to information provided by local community health agents, Mumbuca is composed of 564 inhabitants distributed across 173 families. The community is subdivided into three distinct areas, each under the responsibility of a community health agent who also voluntarily assisted us in guiding the approach to the interviewees. In terms of religious orientation, there is also a predominance of Catholicism, with two Catholic churches in the community. Additionally, the coexistence with other Christian and African-rooted religious expressions is evident. Locally, there are commercial establishments and public infrastructure, including a basic education institution, a community association, a Basic Health Unit (UBS), and a surrounding forest area characterized by the Caatinga ecosystem, according to data from the Brazilian Institute of Geography and Statistics (IBGE) from 2019 (Instituto Brasileiro de Geografia e Estatística – IBGE, 2024).

Both communities were chosen due to the close relationship of their members with the environment, evidenced by the practice of family farming, gardening, among other activities. Additionally, both communities depend on wood resources for various daily activities, such as cooking, medicinal use, technological applications, and especially for magical-religious use, such as making bonfires during the June festivities.

Legal Aspects of the Research

The project adhered to all legal and ethical procedures for research involving human subjects and their associated environmental knowledge. The study was approved by the Research Ethics Committee (CEP) of the Federal Rural University of Pernambuco (UFRPE) through the Brazil Platform at the National Research Ethics Commission (CONEP), under the registration CAAE: 64712522.3.0000.9547. After obtaining the necessary licenses, the first contact with the communities was made through periodic visits, conducting door-to-door conversations accompanied by local health agents. During these visits, the justifications, objectives, and contributions of the research were presented to the communities. All individuals responsible who agreed to participate in the research signed the Free and Informed Consent Form (TCLE), authorizing the collection, use, and publication of the information obtained during the interviews, following Resolution No. 466 of 2012 of the National Health Council.

Participant Profile

All individuals responsible for making the bonfires (men or women) at the time of data collection, aged 18 years or older, and residing in the selected communities, were chosen for this study. In total, we interviewed 150 people, including 76 from the community of Lagoa do Junco in Santana do Ipanema, representing 74.5% of the total sample (102 families). Among the interviewees in this community, 38 (50%) were women aged between 18 and 70 years old, while 38 (50%) were men aged between 18 and 80 years.

In the community of Mumbuca in Coité do Nóia, 74 interviews were conducted, which corresponds to 42.8% of the total sample (173 families). Of these, 34 (45.1%) were women aged between 26 and 73 years, and 40 (54.1%) were men aged between 21 and 77 years.

The low participation rate may have been influenced by various factors, particularly the rural nature of the community and the specific focus of the study (i.e., woody resources). Ethnobiological research suggests that the sensitive nature of topics such as firewood collection and hunting can lead to distrust and create barriers between researchers and the community (Albuquerque *et al.*, 2010; Albuquerque & Alves, 2014a).

Ethnobiological Data Collection

In Situ Inventory

To obtain detailed responses and achieve the objectives of this study, in situ inventories (Ramos & Albuquerque, 2012) were conducted at residences with either assembled or in-process bonfires, to measure the volume of the constructed piles, with the builders' permission, to relate to the knowledge about these resources. This step was used to select participants for this study. Semi-structured interviews (Albuquerque *et al.*, 2005) were then conducted with those responsible for the bonfire construction.

Semi-Structured Interviews

The semi-structured interviews were conducted on June 23, 2022, in the community of Lagoa do Junco, in Santana do Ipanema, and on June 23, 2023, in the community of Mumbuca, in Coité do Nóia.

The semi-structured interviews were divided into two complementary stages in each community. The first stage aimed to gather socioeconomic information, such as name, sex, number of household members, age, and education. The second part of the interview included questions about various aspects related to the tradition of making bonfires during the June period, such as motivations (*Why do you build bonfires during the June period?*), challenges faced (*Are there difficulties in accessing these resources?*), perceived environmental impacts (*Are there any problems associated with lighting bonfires related to nature?*).

Additionally, in this stage of the interview, participants were asked to provide a free list of plant species known and used for making bonfires, using the guiding question: "*What plants do you know that can be used for making a bonfire?*" Participants were then asked to identify which of the listed species were used in making the bonfire.

All botanical material mentioned by interviewees in both communities was collected and deposited in the Herbarium of the Instituto do Meio Ambiente de Alagoas (IMA) for identification. Species that did not present reproductive material, making their collection impossible, were identified using their vernacular names and the geographic location provided by the interviewees, through the REFLORA platform (Flora e Funga do Brasil, 2024). (Available at www.floradobrasil.jbrj.gov.br).

Collective Subject Discourse (CSD)

To enrich the investigation, we applied the Collective Subject Discourse (CSD) technique (Lefevre & Lefevre, 2005). This method was used to qualitatively analyze participants' perceptions of possible health and environmental issues arising from the practice of making bonfires. Open-ended questions were designed to explore these perceptions in depth, and responses were analyzed to capture the collective understanding of these aspects.

The analysis involved reviewing responses collected through semi-structured interviews. The main questions addressed in the interviews were: a) *Do you perceive any health-related problems associated with lighting bonfires?* and b) *Do you perceive any environmental problems associated with lighting bonfires?* Only responses indicating potential environmental and health concerns were selected for CSD analysis. This approach ensured that representative narratives of the interviewees' concerns and perceptions were included, providing a detailed view of the impacts observed from this cultural practice.

Data Analysis

Influence of Socioeconomic Variables on the Use and Knowledge of Species

To assess the influence of socioeconomic variables on the making of bonfires during the June festivities, two distinct statistical models were used to examine the relationship between a response variable and an explanatory variable, utilizing the R programming (R Core Team, 2020). The models were developed using generalized linear mixed models (GLMMs) with the "lme" function (Bates *et al.*, 2014) from the *nlme* package in the R statistical environment.

For the first model, the number of species used and the volume of firewood per person were used as response variables, while the independent variables included in the model were gender, age, education level, number of household members, and family income. For the second model, the number of species known by each individual was used as the response variable, with the same independent variables as in Model 1, i.e., the socioeconomic variables.

To conduct the analysis, socioeconomic data were categorized. Specifically, to evaluate the influence of education, it was categorized into nine distinct strata: 0) illiterate; 1) semi-illiterate (individuals in an intermediate position between literacy and illiteracy); 2) MOBRAL (education from the Brazilian Literacy Movement); 3) incomplete elementary education; 4) complete elementary education; 5) incomplete high school; 6) high school student; 7) complete high school; 8) *Magistério* (a vocational teacher-training course at the secondary level, formerly integrated into high school education in Brazil); 9) complete higher education 10) postgraduate education. The family income was divided into: 0) less than one minimum wage; 1) ≥ 1 and < 2 minimum wages; 2) ≥ 2 and < 3 minimum wages; and 3) ≥ 3 minimum wages. This considers the total income of all household members, given that the minimum wage in Brazil during the interview period was R\$ 1,212.00 (approximately US\$ 387) in 2022 and R\$ 1,320.00 (approximately US\$ 421) in 2023.

Occupations were categorized as: 0) student; 1) self-employed; 2) minimum wage employees (whose salary is



at the legal minimum level); 3) no fixed income (such as individuals working in household chores); and 4) those with nature-related jobs (agriculture, gardening, market vendors). Age and number of residents per household are numerical and, therefore, were not subjected to categorization. The gender variable was differentiated between male and female, while frequency of use was expressed in specific time terms, such as less than a week, one week, one and a half weeks, and two weeks.

Analysis of the Discourse of the Collective Subject (DSC)

To ensure greater accuracy in transcribing the responses, a lapel microphone connected to a Motorola Moto E7 2020 smartphone was used, supported by the Easy Voice Recorder app, version 2.8.6. The technique involved the following steps: (a) extraction of key expressions that characterize each respondent's answers; (b) identification and grouping of these expressions into pre-established central ideas through coding in the database; and (c) construction of the DSC from the central ideas. Volunteers from both communities were asked two questions: 1) Do you observe any health-related problems when lighting bonfires? 2) Do you perceive any nature-related problems when lighting bonfires? This was conducted according to the DSC technique.

Wood Volume Analysis

The measurement of the firewood volume for the bonfires (165 in total) was conducted using the stack dimensions to calculate the stacked volume (m^3), according to the formula proposed by Batista & Couto (2002). This measurement is relevant because the firewood volume was used as a response variable in the generalized linear mixed models (GLMMs) developed for this study. These models allowed us to assess the influence of socioeconomic variables on bonfire construction during the June festivities. Thus, quantifying the firewood volume provides an objective measure that enables robust statistical analyses of the patterns of wood resource use by the studied communities.

$$\text{Stack Volume} = L \times l \times h$$

where:

- “L” represents the length of the stack;
- “l” represents the length of the logs;
- “h” represents the average of the 5 different heights measured from the stack.

Results

Total Wood Volume Used in Bonfires

Considering the total sum of all bonfires built in the Lagoa do Junco community, a total of $76.26 m^3$ of wood was stacked on June 23, 2022, with an average of $0.94 m^3$ of wood per bonfire (Figure 2). In the Mumbuca community, a total of $124.25 m^3$ of wood was recorded for the bonfires, with an average of $1.53 m^3$ per bonfire on June 23, 2023.

Influence of Socioeconomic Variables on Knowledge of Species Used in Bonfire Construction

In both communities, a total of 22 ethnospecies were cited and collected (Table 1). Out of these, 17 species were identified, distributed across 17 genera and belonging to nine botanical families (Table 1). The Fabaceae family was the most prominent in terms of species (10), while the other families each had only one species (Table 1).

Regarding the composition of the bonfires, the majority of the participants used only forest wood, which was either collected from the surroundings of the community by the participants themselves, purchased from local vendors, or brought in from outside the community (75% in Lagoa do Junco and 85.2% in Mumbuca).

A portion of the respondents stated that they did not know which species they were using, as the wood was either donated to them or brought in by relatives, making it difficult to determine the collection conditions and the species of the wood (11.9% in Lagoa do Junco and 13.5% in Mumbuca).

In Lagoa do Junco, some participants built “mixed bonfires,” composed of both reused wood scraps (such as old furniture or construction materials) and forest wood collected from nearby forests or acquired through other means. This practice was reported by 10.5% of the respondents.

Finally, a small portion of participants in both communities reported using exclusively reused wood, such as demolition or renovation materials (2.6% in Lagoa do Junco and 1.3% in Mumbuca).

Among those who knew and used local wood for bonfire construction, it was observed that Jurema (*Piptadenia retusa* (Jacq.) P.G.Ribeiro, Seigler & Ebinger) (Benth.) had the highest citation rate (27%), followed by Catingueira (*Cenostigma pyramidalis* (Tul.) Gagnon & G.P.Lewis) (16.8%), and Cajueiro (*Anacardium occidentale* L.) (12.4%) (Table 1).

Lagoa do Junco community

We did not find a significant influence between the independent variables, such as education ($p > 0.240$), income ($p > 0.879$), age ($p > 0.225$), number of residents in the household ($p > 0.352$), occupation ($p > 0.732$), and frequency of wood use ($p > 0.097$), that could explain the



Figure 2. Panel A shows a bundle of firewood specifically purchased for setting up bonfires. Panel B illustrates a bonfire prepared for burning, predominantly composed of tree roots repurposed from other activities. Panel C displays stakes fixed into the ground to stabilize the bonfires. Panel D shows tarps and plastic bags placed over the bonfires to protect the wood from the frequent rainfall during this time of year.

differences in knowledge of species used for the construction of June bonfires

Mumbuca community

We did not find a significant influence between the independent variables, such as education ($p > 0.245$), income ($p > 0.710$), age ($p > 0.331$), number of residents in the household ($p > 0.535$), occupation ($p > 0.762$), and frequency of wood use ($p > 0.933$), that could explain the differences in knowledge of species used for the construction of June bonfires.

Influence of Socioeconomic Variables on Bonfire Constructions

Lagoa do Junco community

The independent variables, such as gender, education, number of residents in the household, occupation, and

frequency of wood use, did not reveal statistically significant differences that could explain the volume of wood used in bonfire constructions. However, two factors showed statistical relevance: income and age, demonstrating a significant association with a greater volume of wood in the bonfires of the Lagoa do Junco community, as highlighted in Table 2.

Figure 3 illustrates this data, showing a significant relationship between the age of individuals and the amount of wood used for Saint John bonfires. The results indicate a significant trend of increased wood usage as participants' age increases.

When examining the relationship between income and the volume of wood used (Figure 4), it is evident that a significant relationship exists. As shown, individuals with higher incomes tend to use more wood, likely due to greater purchasing power to acquire this resource.

A similar result was observed regarding the level of education (Figure 5), which shows a slight decreasing trend.



Table 1. Species cited and used in the construction of bonfires during the June festivities by respondents from both communities.

Family	Scientific Name	Local Vernacular Name	Voucher	Number of Citations
Anacardiaceae	<i>Anacardium occidentale</i> L.	Cajueiro	MAC0008515*	23
	<i>Mangifera indica</i> L.	Mangueira	MAC0008509*	11
Bignoniaceae	<i>Tabebuia aurea</i>	Pau-d'arco	RB00534596*	5
Burseraceae	<i>Commiphora leptophloeos</i> (Mart.) J. B. Gillet	Amburana	HVASF4817*	3
Euphorbiaceae	<i>Croton blanchetianus</i> Baill.	Marmeleiro	IMA68301	19
Fabaceae	<i>Anadenanthera macrocarpa</i> (Benth.) Brenan	Angico	HEPH00007201*	12
	<i>Bauhinia cheilantha</i> (Bong.) Steud.	Mororó	IMA68309	1
	<i>Bauhinia variegata</i> L.	Junqueiro	IAN187667*	1
	<i>Bowdichia virgilioides</i> Kunth	Sucupira	RB01403726*	2
	<i>Cenostigma pyramidale</i> (Tul.) Gagnon & G.P.Lewis	Catingueira	IMA68304	31
	<i>Melanoxylon brauna</i> Schott	Braúna	HUEFS130425*	1
	<i>Piptadenia retusa</i> (Jacq.) P.G.Ribeiro, Seigler & Ebinger	Jurema	IMA68310	50
	<i>Mimosa sensitiva</i> L.	Rasga-beiço**	IMA68306	2
	<i>Prosopis juliflora</i> (Sw.) DC	Algaroba	ASE0028902*	9
	<i>Eucalyptus citriodora</i> Hook.	Eucalipto	MUFAL0000001594*	1
Rhamnaceae	<i>Sarcophthalus joazeiro</i> (Mart.)	Juazeiro	IMA68300	9
Rubiaceae	<i>Guettarda sericea</i> Müll.	Facheiro	IMA68305	1
	Unidentified 1	Cabotão	***	1
	Unidentified 2	Canzenzo	***	2
	Unidentified 3	Murici	***	1

*Ethereal species were not found to be fertile and were identified through the virtual herbarium Re flora. **Rasga-Beíço (*Mimosa sensitiva* L.) is a non-woody plant, used only for igniting the fire. *** Ethnospecies not identified as they were not found in the collection areas.

Table 2. Generalized Linear Mixed Model (GLMM) results for socioeconomic variables associated with greater wood volume used for Saint John bonfires in the community of Lagoa do Junco, Santana do Ipanema, Alagoas, Northeastern Brazil.

Socioeconomic Variables	Sum Sq	Df	F value	P Value
Age	0.3617	1	4.0474	0.04933 *
Level of education	0.0145	1	0.1620	0.68894
Number of residents	0.0229	1	0.2560	0.61497
Family Income	1.5666	3	5.8437	0.00159 **
Occupation	0.7178	4	2.0081	0.10665
Frequency of Use	0.2294	1	2.5667	0.11508

This indicates that individuals with lower education levels tend to use more wood for bonfire construction.

Mumbuca community

Independent variables such as gender, age, education level, number of household residents, occupation, and frequency of use did not indicate significant differences explaining factors that influence the volume of wood in bonfire construction. However, income again emerged as a factor, showing a notable correlation with the larger volume of bonfires in the Mumbuca community (Table 3).

The analysis reveals a significant positive correlation between income and the volume of wood used (Figure 6), indicating that the higher the participants' income, the

greater the volume of wood used for the construction of Saint John bonfires. Additionally, we found a significant relationship between age and wood volume (Figure 7), indicating a negative trend. This analysis shows that as individuals age, their use of wood for bonfires decreases.

Perception of the Impacts of Making Juninas Bonfires

The subsequent tables present data concerning the DSC. These tables (Table 4, Table 5) delineate the associations between the Central Idea and key expressions, with a proportional distribution of responses based on the participants' opinions. In general, while a small portion of the informants mentioned individual perceptions of

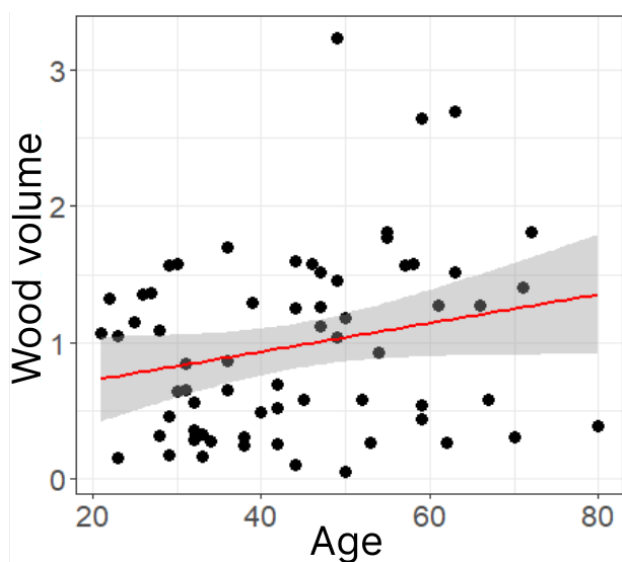


Figure 3. Distribution of interviewees' ages and their respective volumes of wood used in Lagoa do Junco, a community in Santana do Ipanema, Alagoas, Northeastern Brazil.

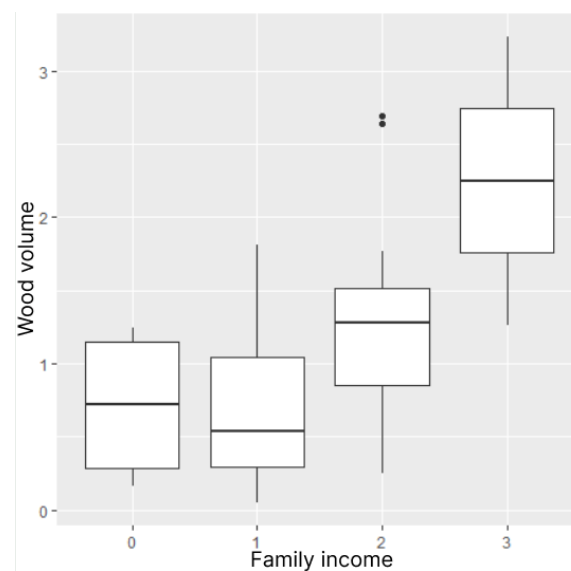


Figure 4. Comparison between the family income of interviewees and the volume of wood used in Lagoa do Junco, a community in Santana do Ipanema, Alagoas, Northeastern Brazil.

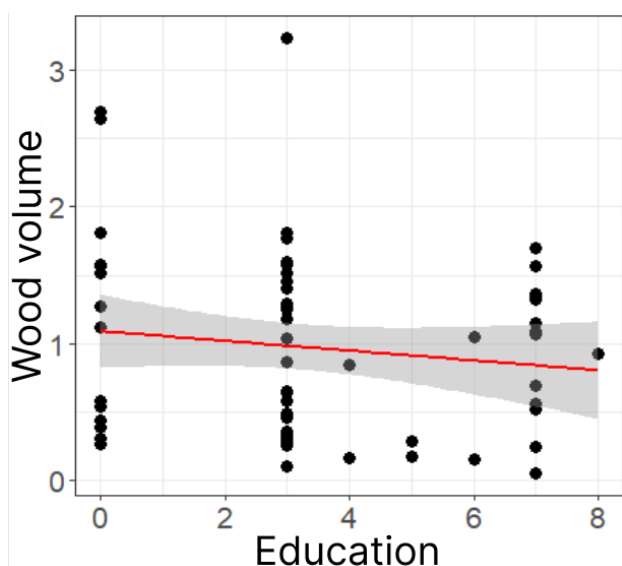


Figure 5. Representation of a negative correlation between the education level of interviewees and the volume of wood used in the community of Lagoa do Junco, Santana do Ipanema, Alagoas, Northeastern Brazil.

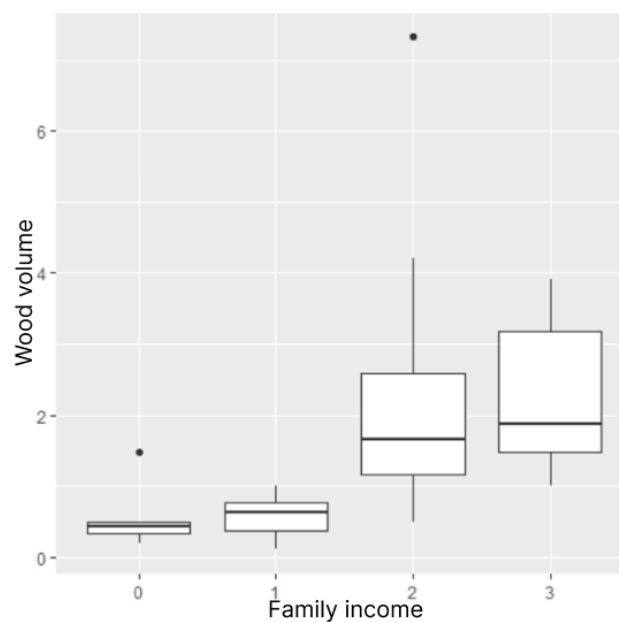


Figure 6. Comparison between the household income of interviewees and the volume of wood used in Mumbuca, a community in Coité do Nória, Alagoas, Northeastern Brazil.

negative impacts related to the construction of June bonfires (e.g., deforestation, increase in local temperature, skin burns, smoke inhalation), the majority did not. This suggests a limited awareness among most participants regarding the health risks and environmental impacts caused by this activity.

Regarding environmental impacts, at the Lagoa do Junco community, six interviewees (7.9%) reported problems

related to making juninas bonfires, while 70 interviewees (92.1%) did not perceive any issues. In the Mumbuca community, 13 interviewees (17.6%) perceived problems, compared to 61 interviewees (82.4%) who did not.

Concerning the perception of health-related problems, 27.7% of interviewees from the Lagoa do Junco community reported direct effects from the bonfires, while in the Mumbuca community, this percentage was 28.4%. Regarding



Table 3. Generalized Linear Mixed Model (GLMM) results for socioeconomic variables associated with greater wood volume used for Saint John bonfire construction in the community of Mumbuca, Coité do Nória, Alagoas, Northeastern Brazil.

Socioeconomic Variables	Sum Sq	Df	F value	P Value
Age	0.1050	1	0.8235	0.3681
Level of education	0.0004	1	0.0029	0.9571
Number of residents	0.0069	1	0.0541	0.8169
Family Income	6.7844	3	17.7279	3.564 e -08 **
Occupation	0.5345	4	1.0476	0.3912
Frequency of Use	0.1304	2	0.5112	0.6026

Table 4. Key expressions and central ideas from the Collective Subject Discourse on the health impacts of bonfire making in the communities.

Category	Central Idea	Key Expression
Respiratory Problems	"Causest respiratory problems"	"I think it causes respiratory problems; some people have asthma, sinusitis, and it's harmful, right? We do this [make bonfires], but a lot of people are not aware..." (Community of Lagoa do Junco) "After this COVID [SARS-CoV-2 pandemic], we saw a lot of respiratory problems, [...] those who had something [respiratory issues] had more difficulties, so I see it more in terms of smoke." (Community of Mumbuca)
Burn risks	"Easier to get burned"	"Yes, right, it's easier to get burned because of the bonfires, right? I've seen many kids step and get burned because they play near the bonfires." (Community of Lagoa do Junco)
Eye irritation	"They make our eyes tired"	"They make our eyes tired; it's horrible to walk around at night like this." (Community of Lagoa do Junco) "It causes a lot of problems for the eyes, making them itch and turn red." (Community of Mumbuca)
Noise Pollution	"The noise from the firecrackers"	"The noise from the fireworks scares us, and the dogs too. They get so nervous it could even cause heart attacks."* (Community of Lagoa do Junco)
Allergies		"There are indeed allergies, especially, people have asthma, rhinitis, and can suffer from smoke poisoning." (Community of Mumbuca)

*A discourse can present more than one central idea.

Table 5. Key expressions and central ideas from the Collective Subject Discourse of the communities regarding the environmental impacts of June bonfires.

Category	Central Idea	Key Expression
Emission of Pollutant Gases	"Pollution caused by the smoke"	"It causes a lot of pollution; the air becomes bad, harms us and consequently the planet, increasing the greenhouse effect." * (Community of Mumbuca) "The pollution that smoke causes to the planet and the deforestation of trees to make [the bonfires], right? I myself only use dry wood..." (Community of Lagoa do Junco)
Deforestation	"The deforestation"	"When there is tree felling, because besides people taking them for themselves, they also take them to sell, and this is harmful." (Community of Mumbuca) "Deforestation... many people take green wood or cut it to sell." (Community of Lagoa do Junco)
Risks of killing animals	"Sometimes there is a bird's nest in the tree and someone goes and knocks it down."	"Now I see, I see a lot of deforestation of trees... people keep taking green wood and it affects nature, even the animals. Sometimes there is a bird's nest in the tree and someone goes there and knocks it down, you know? And kills the bird." (Community of Mumbuca) "The noise from the fireworks scares us and the dogs too; they get nervous and it can even cause heart attacks."* (Community of Lagoa do Junco)

*A discourse can present more than one central idea.

environmental risks, only 5.3% of interviewees from the Lagoa do Junco community identified problems, whereas in the Mumbuca community, this percentage was 17.6%.

The data on perceived health risks for the populations of the Lagoa do Junco and Mumbuca communities were analyzed, as shown in Figure 8. The analysis highlighted the

main health issues associated with the practice of building bonfires during the June period. Among the reported risks, “respiratory problems” emerged as the predominant category, most frequently mentioned by both communities. Other associated risks included burns, shortness of breath, and allergic reactions, all linked to the practice of burning wood during the festivities.

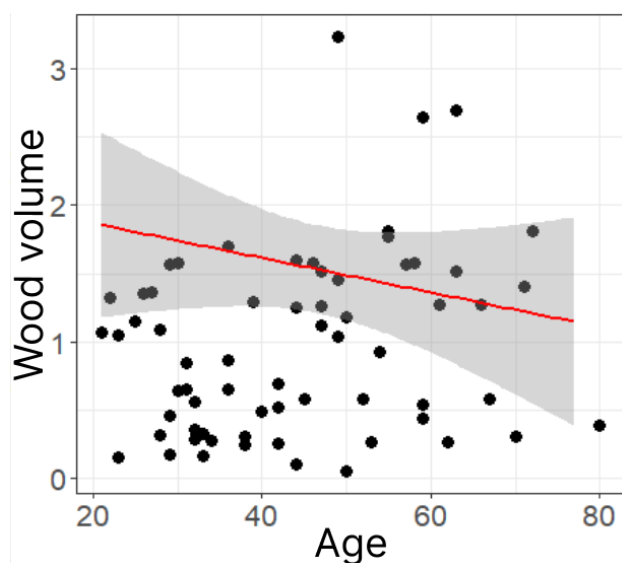


Figure 7. Representation of a negative correlation between the age distribution of interviewees and the volume of wood used in Mumbuca, a community in Coité do Nôia, Alagoas, Northeastern Brazil.

Discussion

Do Socioeconomic Variables Influence the Knowledge and Use of Species in Bonfire Making?

In comparison, a similar study conducted by Almeida *et al.* (2008) recorded total wood volumes for Saint John celebrations of 39.27 m³ in 2007 and 74.15 m³ in 2008, with respective averages of 0.715 m³ and 0.861 m³ per bonfire. When the volumes from all three celebrations (Saint John, Saint Anthony, and Saint Peter) over the two years were summed, the total reached 146 m³ for 114 bonfires, resulting in a general average of 1.52 m³ per bonfire.

On the other hand, the volumes recorded in the communities studied in this work (76.26 m³ in Lagoa do Junco and 124.25 m³ in Mumbuca) amounted to a total of 200.51 m³ solely for Saint John celebrations. The averages observed were 0.94 m³ per bonfire in Lagoa do Junco and 1.53 m³ per bonfire in Mumbuca. The average for the

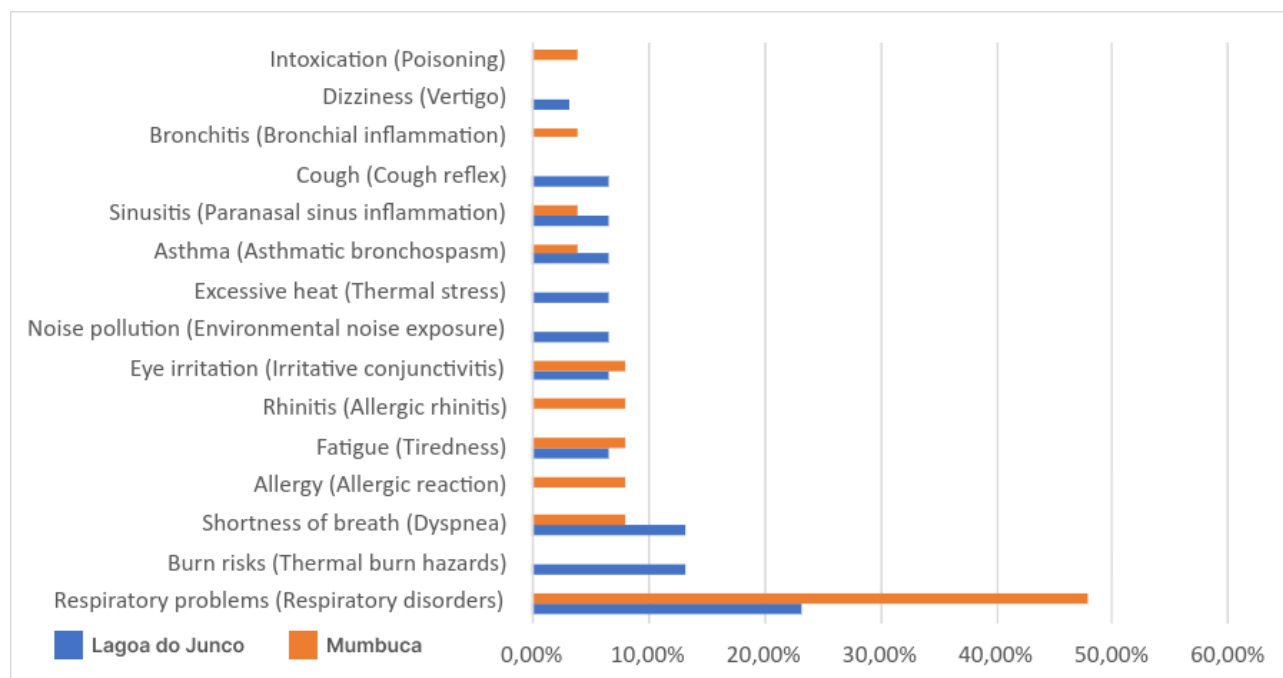


Figure 8. Comparison of health risk perceptions between the communities of Lagoa do Junco and Mumbuca related to bonfire making during the June festivities.



Mumbuca community is slightly higher than the general average found in Almeida *et al.* (2008) study (1.52 m³), while the average for Lagoa do Junco is lower, which shows that there is no standard timber volume for this type of use.

It is important to highlight the contextual differences between the studies when interpreting these results. In the communities of Lagoa do Junco and Mumbuca, there are no formal restrictions on wood collection. In contrast, the community of Três Ladeiras analyzed by Almeida *et al.* (2008) faced strict regulations prohibiting wood extraction from forested areas owned by a local factory, Fábrica São José. Despite these restrictions, the Três Ladeiras community was able to construct significant bonfires through adaptive practices such as collecting wood from non-forested areas (67.3%), using dry or dead wood available in forested areas (20.6%), and gathering wood from agricultural lands (11.3%).

These strategies demonstrate the cultural resilience of the community in maintaining its June festival traditions despite regulatory limitations. However, it is crucial to consider that such practices may have significant environmental implications and should be taken into account when assessing the impact of woody resource use in different contexts.

However, the list of species used for bonfire making was relatively limited, including only 17 species distributed across nine botanical families. Furthermore, the botanical families with the highest number of species were Fabaceae, Anacardiaceae, and Rhamnaceae. Various ecological and ethnobiological studies highlight the physical and chemical properties that facilitate the use of these species for various domestic purposes (Ramos *et al.*, 2008b; Medeiros *et al.*, 2011; Nascimento *et al.*, 2019; Hora *et al.*, 2021; Mendes *et al.*, 2024).

The high presence of these families in various studies on wood resources suggests a pattern of consistent knowledge, extraction, and use of species from these families by human communities within the Caatinga ecosystem (Mendes *et al.*, 2023). This indicates a certain uniformity in the behavior of using well-known and widely utilized timber species across the communities, as people tend to rely on a specific set of species for all categories of timber use. However, this result contrasts with the findings of Almeida *et al.* (2008), where participants demonstrated a distinct pattern of firewood selection for bonfires compared to that used for daily activities, such as cooking. Furthermore, our findings suggest that these species are subject to varying types of extraction throughout the year: there is a continuous demand for domestic purposes and, periodically, an increased demand during the June festivities. This highlights the need for attention to these species within their environments due to their dual-purpose exploitation.

The observation of low species diversity and the significant presence of the Fabaceae family, for example,

may indicate that the use of wood for making June bonfires is primarily linked to categories of use that require the selection of species with favorable characteristics for fuel or that have high ecological attributes, such as abundance and availability of individuals (Hora *et al.*, 2021; Mendes *et al.*, 2024). These evidences are observed in studies investigating human behaviors regarding the selection and preference of wood species for food cooking (Ramos *et al.*, 2008a; Medeiros *et al.*, 2014; Hora *et al.*, 2021; Mendes *et al.*, 2024), where species from the Fabaceae family always stand out in terms of citation numbers, such as *Cenostigma pyramidalis* (Catingueira) and *Piptadenia retusa* (Jurema).

This limited use observed in this investigation might be seen as an adjustment to local circumstances where certain species are more abundant or easier to collect due to specific environmental conditions, in addition to indicating that the extraction of these resources occurs in forested areas near these communities, as species from the Fabaceae family are found in the surrounding forest areas of human communities in the caatinga (Ramos *et al.*, 2008a; Medeiros *et al.*, 2014; Hora *et al.*, 2021; Mendes *et al.*, 2024).

Additionally, it was observed that some socioeconomic factors may influence the volume and number of species used for making bonfires, but do not affect the number of species known for this purpose, also indicating a homogeneity in the knowledge of species among the communities. In this regard, a positive relationship was observed between the volume of wood used for making bonfires and the income of the participants in both communities. This result may be related to behaviours such as the purchase of timber resources for the construction of these bonfires. Several studies corroborate our findings, demonstrating that higher-income households tend to purchase larger quantities of wood, typically acquired from distribution centres located near their residences, such as markets or natural resource vendors (Gregory, 1966; Kayo *et al.*, 2015; Álvarez *et al.*, 2021). This behaviour may have also contributed to the homogenisation of knowledge regarding the species used in both communities, as it is likely that the customer has the option to choose the type of wood they desire.

Furthermore, this purchasing practice might reflect a significant increase in pressures from resource extraction, such as a significant decline in ecological abundance and availability rates of used species, as commercial-scale collection tends to be much higher compared to individual or domestic extraction (Álvarez *et al.*, 2021; Mendes *et al.*, 2024).

On the other hand, this result may have been directly influenced by the periodic nature of wood use for bonfires, as this usage does not occur continuously. In other words, income plays a significant role in the purchase of wood resources during the bonfire construction period associated with the June festivities, reflecting the specificity of this category and contrasting with studies that interpret the

use of wood resources daily as subsistence resources, such as firewood for cooking (Ramos *et al.*, 2008b; Medeiros *et al.*, 2014; Soe & Yeo-Chang, 2019). That is, the cultural periodicity characteristic of bonfire construction for magical-religious celebrations may have a greater influence on the adoption of specific behaviours, as families with higher income tend to opt for purchasing species rather than spending energy on the process of selecting and extracting species from the natural environment.

Nonetheless, we must still consider that the specific characteristics of this community may have influenced these results, including the presence of a higher number of families with a per capita income greater than one minimum Brazilian wage, as well as the peri-urban nature of the community. This profile may facilitate both the extraction of these resources from the natural environment, as well as from other sources, where access to the city may ease purchasing, thereby increasing the use of species for bonfire construction.

Regarding the age variable, a positive correlation was observed between species use and the age of individuals in the Lagoa do Junco community. Studies show that older individuals possess greater proficiency in knowledge related to timber resources, particularly those used in daily activities for various purposes (Oliveira da Silva *et al.*, 2017; Mahmoudi *et al.*, 2023). Investigations such as those conducted by Oliveira *et al.* (2017) suggest that this interrelation between variables (i.e., wood volume and age) is classified as a phenomenon based on the strong connection that older individuals maintain with culturally and traditionally significant elements, directly influencing the encouragement of cultural practices (Lunelli *et al.*, 2016).

However, we identified a contrary association between these same variables (age and volume of wood) in the Mumbuca community. This phenomenon suggests a possible correlation with the difficulty of accessing timber resources, as results indicate that older individuals (38 to 65 years) report difficulties in collecting these resources. Additionally, despite the absence of formal prohibitions on natural resource extraction, respondents from the Mumbuca community need to travel longer distances to obtain wood due to the occupation of nearby areas by agricultural and livestock activities. Furthermore, concerning knowledge, factors such as cognitive decline associated with ageing may also hinder the recall and recognition of species by older individuals within this group (Meireles *et al.*, 2021).

However, it is important to emphasise that the interpretations of the results of this study must take into account the discrepancy between the specific contexts analysed. Older adults in the studied community of Lagoa do Junco may also face challenges in acquisition and knowledge. However, the ease of purchasing and accessing information about resources may be greater compared to those in the Mumbuca community.

Additionally, a proportional inverse influence was observed between the variables education and volume of wood. Where a reduction in educational level is associated with an increase in the volume of wood used (Figure 5). This finding aligns with studies indicating that lower educational levels can lead to greater use of natural resources in cultural and magical-religious practices, due to reduced environmental awareness and limited access to information about sustainable practices (Karim, 2022).

Furthermore, the strong cultural tradition of building June bonfires in this peri-urban community may amplify this effect. Deeply rooted cultural practices often prioritize the preservation of traditions over environmental considerations (Albuquerque & Hanazaki, 2009; Reyes-García *et al.*, 2011). This contrasts with the Mumbuca community, where there is a lower proportion of individuals with low educational levels (44.4%) and a higher proportion of individuals with higher educational levels (55.6%) compared to Lagoa do Junco, which has a rate of 59.5% for lower educational levels.

The gender variable did not show an influence on the knowledge and use of wood for making bonfires in both communities, indicating homogeneity in knowledge between men and women regarding this cultural practice. This result suggests that both the knowledge and acquisition of timber resources for this practice are transmitted equally across generations, allowing both genders to acquire the same skills and information without being restricted to a specific social role. This contrasts with studies in other local communities that generally show men having greater knowledge about timber resources than women, due to practices associated with their social roles, such as agriculture (Arruda *et al.*, 2019; Silva *et al.*, 2016a).

Furthermore, when analysing the number of people per household, no significant relationship was found with the knowledge and use of resources, unlike the findings observed in studies examining the daily use of timber resources, which indicate a positive relationship between an increase in household size and higher consumption of natural resources (Gavin & Anderson, 2007; Medeiros *et al.*, 2012; Arruda *et al.*, 2019). This result may again be influenced by the periodic nature of bonfire construction during June, as, for example, in daily use, the amount of wood for cooking may vary depending on the number of people in a household and the amount of food required to meet the demand of these people.

Through the results of the socioeconomic data, we can observe that our findings suggest that the cultural and periodic characteristic of the magical-religious use of bonfires for celebrations directed to Catholic saints (such as Saint John, Saint Anthony, and Saint Peter) has a direct influence on the presence of specific behaviours that distinguish this practice from other categories commonly studied in the ethnobiological context.



Perception of the Impacts of June Bonfire Making

In relation to the perceptions of individuals regarding how the construction of bonfires affects health, the majority of participants from both communities did not express concerns regarding potential impacts. The justification for this lack of awareness and concern was explained by the participants, who cited the seasonal nature of the June festivities, which occur only over a short period of the year (Oh *et al.*, 2022).

When specifically evaluating the small number of residents who reported health impacts associated with the June bonfire activities in the studied communities (Figure 8), it was observed that the predominant risk identified by both communities was 'respiratory problems,' suggesting that a small segment of the communities shared concerns regarding these specific and simultaneous symptoms related to the process of building bonfires.

This perceptual gap may be influenced by the intrinsic characteristic of bonfire construction, that is, the seasonality of the festivities. In this regard, the seasonality of the event may affect how risks are perceived, suggesting that the frequency of certain phenomena may have a greater influence on risk perception in human communities, while more seasonal phenomena have a lesser impact on risk perception regarding the health problems that this event may cause. In other words, people do not perceive the risk related to health problems caused by bonfires because these issues do not occur frequently, unlike problems that are caused more often, as observed in some studies, where people tend to give more attention and concentrate treatment strategies on recurring diseases in their daily lives (Santoro *et al.*, 2015; Nascimento *et al.*, 2019).

Furthermore, another factor that may influence the perception of risk regarding the health problems caused by the construction of bonfires is the type of experience the interviewee has had. For instance, an individual's risk perception regarding the health impacts resulting from bonfire construction may vary depending on their experience, whether direct (the individual themselves experienced health issues due to the bonfires) or indirect (relatives, neighbours, or friends experienced health problems due to the bonfires) (Wachinger *et al.*, 2013; Silva Santos *et al.*, 2023).

Another important factor to highlight is that most participants from both studied communities did not identify environmental impacts resulting from the practice of building bonfires during the June period. This homogeneity in environmental perception suggests that both Lagoa do Junco and Mumbuca residents share a relatively similar level of environmental awareness regarding the impacts of this seasonal practice.

This homogeneous perception may be related to the periodicity of June bonfires, which occur only once a year, reducing participants' attention to potential cumulative environmental damage. Additionally, the strong cultural

tradition associated with bonfires may contribute to a more symbolic view of wood use, minimizing concern about its ecological consequences. Previous studies have shown that deeply rooted cultural practices can influence how communities perceive and manage natural resources (Albuquerque *et al.*, 2014b).

Despite this homogeneous perception, our data indicate a concerning mismatch between the lack of recognition of environmental impacts and the actual damage caused by intensive wood extraction and use. Specific studies on June bonfires suggest strategies to balance tradition and environmental conservation.

These findings align with other studies that demonstrate relatively uniform environmental awareness between the Lagoa do Junco and Mumbuca communities in certain cultural contexts (Olivos *et al.*, 2011; Sierra-Barón *et al.*, 2023).

In this sense, these highlights represent various environmental issues, especially regarding how the actual state of natural landscapes might be suffering from intense natural resource exploitation. For instance, Yigezu & Jawo (2021) state in their study that switching from firewood to effective fuel sources can effectively reduce the annual volume of firewood used by rural communities in southern Ethiopia by up to 1.2 tons. In general, this approach can lead to more effective conservation of forest fragments near these communities.

We believe that the mismatch between the perception of negative effects of an activity that can bring harm to health (smoke) and, to a lesser extent, to the environment (seasonal activity), can be problematic, as it can directly hinder efforts to mitigate these damages. Therefore, direct intervention studies in these communities are necessary, especially to understand the ecological pressure that these species may face, and to develop environmental education plans aimed at increasing environmental awareness.

Even though some of the variables studied here exhibit characteristics similar to those found in other ethnobiological studies, particularly those focusing on the use of firewood for cooking, our findings suggest that the cultural and seasonal nature of the magical-religious use of bonfire-making for celebrations dedicated to Catholic saints (such as Saint John, Saint Anthony, and Saint Peter) may have a greater influence on the presence of specific behaviours.

These behaviours reflect a generalist tendency in the use of these resources, which is justified by the significant presence of wood purchases, the use of wood remnants from other functions (e.g., damaged stakes), and even household furniture. It is worth noting that these generalist behaviours are influenced by the seasonality of fire-making, as this activity does not necessitate the selection of wood based on intrinsic attributes that favour its use as fuel. These behaviours distinguish this practice from other categories commonly studied within the ethnobiological field. This highlights the need for studies more focused on the specific

differences in usage, especially those aiming to practically test how this seasonality influences extraction behaviours. This would enable the design of control and conservation measures for natural resources to reduce environmental and health impacts caused by the practice of bonfire-making.

We emphasise that our study did not aim to measure the direct impacts of fire-making; however, we highlight the need for further research focusing on how these resources reach communities, which parts are utilised, and which areas are being affected by this use. Despite being a seasonal activity, the generalist behaviour of extraction and use may exert significant pressure on forested areas, particularly on species that are already subject to exploitation for other purposes in the daily lives of the community.

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Author's Contribution

Silva JCO: Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing; Mendes CHT: Conceptualization, Writing – original draft, Writing – review & editing; Silva ML: Conceptualization, Writing – original draft, Writing – review & editing; Silva TC: Conceptualization, Data curation, Software, Writing – original draft, Writing – review & editing.

Conflict of interest

The authors declare no conflicts of interest.

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